Physical hydrogels composed of alginate and poly(2-hydroxyethyl methacrylate)

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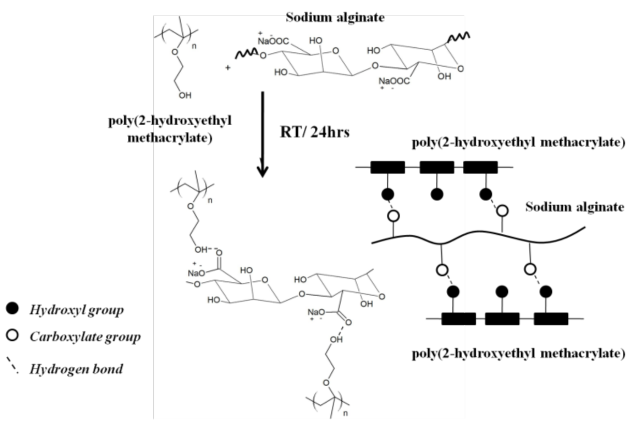
Aim

Purification of wastewater coming from industry as heavy metals and dyes is a critical step to protect water resources. Hydrogels can be used as adsorbents for water treatment.

In this project, we incorporated sodium alginate and poly(2-hydroxyethyl methacrylate) (See synthetic scheme). More precisely, physical cross-linking based on hydrogen bonding between both. Different hydrogels with different percentages of gelation were prepared by varying the molar ratio between sodium alginate and poly(2-hydroxyethyl methacrylate).

First Part: Synthesis and characterization of hydrogels



Scheme 1. Hydrogel based on alginate and poly(hydroxyethyl methacrylate) via hydrogen bond interaction

Different hydrogels is prepared with different gelation percent 18, 25, 32 %, according to the following equation

$$Gelation\ \% = \frac{W}{W_0} \times 100$$

Where W and W_0 are the weight of sodium alginate and weight of purified hydrogel, respectively.

FT-IR:

- IR spectra of the three hydrogels showed characteristic peaks of alginate and poly(hydroxyethyl methacrylate) (PHEMA). Peak around 3420 cm^{-1} indicates the stretching of hydroxyl groups of alginate and PHEMA . the peaks around 1620 and 1420 cm^{-1} related to carboxylate group $-COO^-$, these results are in good agreement with in the literature. Moreover the peak characteristic of carbonyl groups of ester presence in PHEMA is shown at 1735 cm^{-1}.

Thermal behavior

TGA of sodium alginate show to two degradation process, one process occurred over the range of temperature from 246 - 275 ºC is coming from the decarboxylation and liberation of CO_2. Second degradation is observed from 625 – 700 ºC due to the depolymerization of the polymer which leads to carbonaceous residue and Na_2CO_3. TGA of Hydrogels show two stages indicate on alginate and PHEMA .

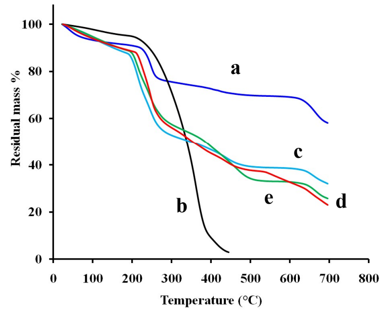


Fig 1. TGA of a) Sodium alginate b) PHEMA c) Hydrogel (1:1 / Alg:PHEMA), d) Hydrogel (1:2 / Alg:PHEMA) and e) Hydrogel (1:3 / Alg:PHEMA)

Morphology

SEM images of sodium alginate and its hydrogels with different content of PHEMA 18, 25 and 32% are shown in Fig.2. SEM images showed the formation of white aggregates indicating the presence ofPHEMA. After increasing the concentration of PHEMA above certain concentration so it is occurred swelling due to interaction among PHEMA and alginate as shown in Fig. 2 (d).

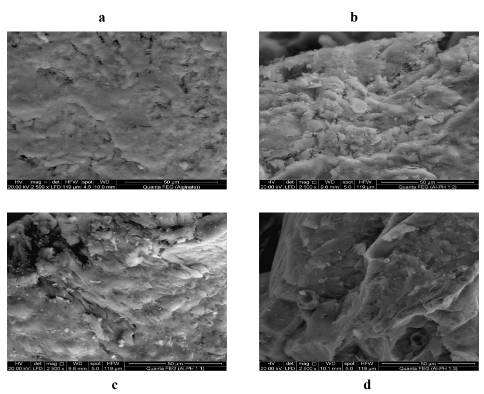


Fig 2. SEM of a) Sodium alginate b) Hydrogel (1:1 / Alg:PHEMA), c) Hydrogel (1:2 / Alg:PHEMA) and d) Hydrogel (1:3 / Alg:PHEMA)

Second Part: Applications

Metal Uptake

- Hydrogels based on alginate and poly(4-vinylpyridine) showed adsorption of metal ions (Cr^{6+}, Cu^{2+}, Ni^{2+} and Cd^{2+}) higher than calcium alginate.
- In case of Cr^{6+} ions, shown in the Fig 3.

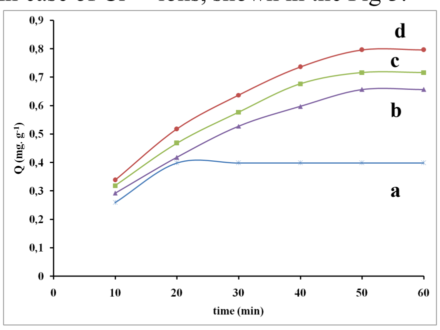


Fig 3. Relations between metal ions uptake
a) calcium alginate
b) Hydrogel (1:1 Alg:PHEMA),
c) Hydrogel (1:2 / Alg:PHEMA)
d) Hydrogel (1:3 / Alg:PHEMA)

Conclusions

- Hydrogels based on alginate and different percentage of poly(hydroxyethyl methacrylate) were successfully prepared.

- Hydrogels based on alginate and different percentages of PHEMA showed adsorption of heavy metal ions more than calcium alginate.

- The prepared physically cross-linked hydrogels based on alginate and PHEMA can be used with highly efficiency for industrial wastewater treatment